RESEARCH NOTES
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LIDAR Technology Provides An Advanced Tool for Landslide Mapping in Heavily Forested Terrain

RESULTS: The Caltrans' GeoResearch Group, in collaboration with the Department of Conservation, successfully used LIDAR technology to map landslides along two heavily forested highway corridors in Humboldt and Del Norte Counties. LIDAR (*Light Detection And Ranging*) is a technique that uses reflections from lasers to determine distance, similar to a survey total station, but is typically performed aerially using a denser array of laser sources from a small aircraft. LIDAR has an advantage over conventional mapping methods in that it can effectively map true ground surface, and not just treetops in heavily forested areas. The LIDAR survey will be used in conjunction with traditional interpretation of aerial photographs and field methods to prepare landslide maps of two demonstration corridors.

Why We Pursued This Research

Mapping landslides in heavily forested terrain can require an extraordinary field effort to identify and characterize landslide features. In many cases resources available for landslide mapping is limited, and the resulting maps tend to be less complete or less accurate than those in un-forested land. This is because landslides are mapped based on their geomorphology, or attempts to explain features found and processes operating upon the surface of the earth. The distinctive landforms created by landsliding must be identified through aerial photographs, topographic maps, or through field reconnaissance. In heavily forested terrain, neither aerial photos nor photogrammetrically prepared topographic maps depict the true ground surface. Photos, of course, show the tops of the trees, but topographic maps also are prepared from photos showing the tops of the trees using an assumed tree height to determine approximate ground elevations. Because these conventional reconnaissance techniques are not that effective, either extra effort is spent on the ground or a less accurate map is produced.

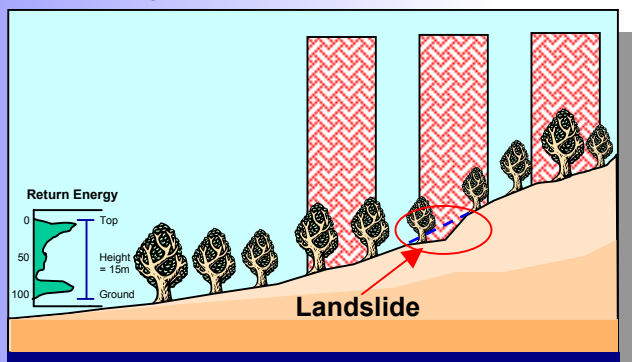

Fig.1: Concept of LIDAR for landslide mapping

LIDAR is a technique that could dramatically improve the speed and accuracy of landslide mapping. LIDAR stands for *light detection and ranging* and uses a system that is essentially a laser rangefinder, which pulses rapidly and scans an area from an aircraft. Airborne Global Positioning Systems (GPS) and inertial navigation on the aircraft allow for the precise location of each reflection off of the ground or other obstructions. A computer system filters the distance measurements, retaining those that reach the ground and rejecting reflections from trees. The result is a detailed digital elevation model (DEM) of the ground surface, often referred to as a "bare earth" DEM. The DEM can be processed in a Geographic Information System (GIS) to make a traditional topographic contour map or a shaded relief map to aid interpretation. The DEM's can be much more detailed and more accurate than either the available USGS topographic DEM's or photogrametric topographic maps.

Fig.2: Small aircraft used for LIDAR survey

What We Did

To test the application of LIDAR to landslide mapping, the Department of Conservation (DOC) commissioned a

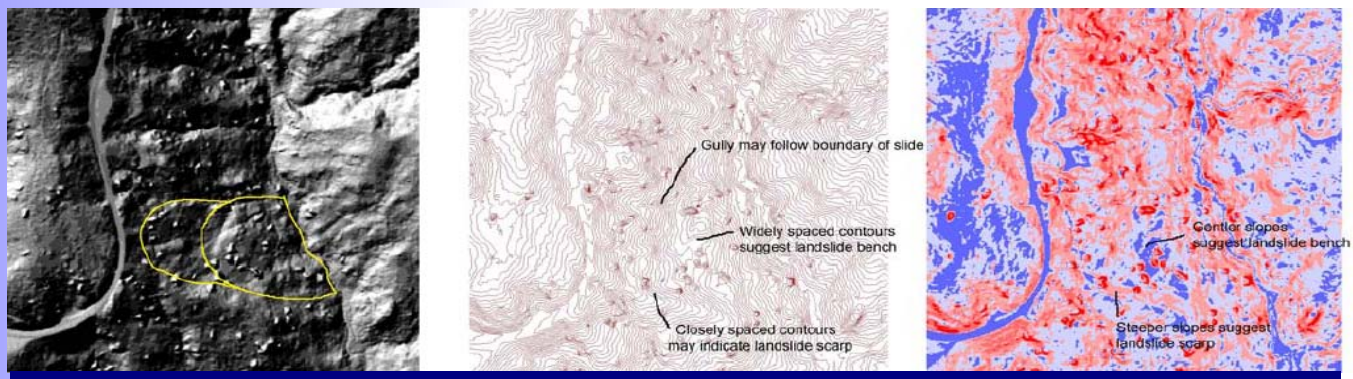

Fig. 3: Shaded-relief (Left), contour map (center) and slope map (right) of a part of the Highway 299 corridor showing how some representative landslide features are expressed in those maps. Yellow outline on the shaded-relief map (left) represents a landslide, as indicated by the features labeled on the contour and slope maps.

LIDAR survey along the Highway 299 corridor in Humboldt County and the Highway 101 Corridor in Del Norte County. Landslides are common along the Highway 299 corridor, and the combination of dense forest cover and rugged topography made aerial photo-based landslide mapping a difficult task. Under this contract the DOC prepared specifications and contract documents to acquire the survey from two pre-qualified LIDAR vendors (3Di and Sanborn).

The contract included the LIDAR survey, the production of DEMs, and the interpretation of landslide geomorphology from the DEMs, The DOC checked the LIDAR-based maps and interpretations through comparison with previously mapped landslide features along the Highway 101 corridor and the Highway 299 corridor.

Fig.4: Navigation and LIDAR processing

Figure 3 shows a shaded relief image, a contour map, and a slope map developed using LIDAR data. Each map reveals features characteristic of landslides and could be used in combination with traditional interpretation of aerial photographs.. This mapping of landslides is very similar to mapping using aerial photos, except that the view of the earth's surface is more detailed and is unobstructed by trees.

The results of two independent LIDAR surveys along one corridor, delivered in July and August 2002, demonstrated that LIDAR can expose landslide details otherwise unattainable through conventional aerial photography. However, the two surveys did provide substantially different densities of bare earth reflections in the most densely vegetated areas. The bare earth DEM of one vendor (Sanborn Colorado) showed considerably more terrain detail, thereby revealing more landslide features. This may be attributed to the calibration of the LIDAR system. Another current Caltrans research project is aimed to investigate the calibration effect.

What the Researchers Recommend

Processing LIDAR-based DEMs into shaded-relief, slope, and contour maps allows geologists to make more detailed and accurate landslide maps than the use of aerial photographs alone. This study demonstrated that LIDAR can be a useful tool in the mapping of landslides. A field reconnaissance study is underway to verify the findings from the LIDAR survey with actual features on ground.

A detailed examination of the comparative quality and time needed to prepare landslide maps of this area using traditional techniques and the LIDAR surveys will be conducted in the near future as part of CGS's mapping of the Highway 299 corridor. The mapping based on the LIDAR survey is being incorporated into landslide and geologic maps being prepared for Caltrans.

The deliverables of this study includes specifications for contracting LIDAR survey projects and a report that summarizes the results of the LIDAR surveys and their applicability to landslide mapping. These products will be available on the web site of the GeoResearch Group.

For More Information on GeoResearch Projects

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